MULTIZONE STIMULATION USING WAX BALLS

Field of the Invention

The invention relates to improvements in multizone stimulation processes used in the oil and gas industry.

Review of the Art

During the production of oil (or gas) a process known as *multizone stimulation* is often used. This process involves drilling an elongate shaft also known as a well which is then sealed at one end. A down-hole tool, known as a perforating gun, is used to generate perforations in the side walls of the shaft, at a pre-set point. Chemicals are then pumped into the surrounding rock to break down the structure of the rock strata, such that oil can subsequently be more efficiently removed from the surrounding strata (or area).

Sealants such as polypropylene balls or small flat wax frits – known in the industry as 'diverters' or 'Frac Balls' - are then passed into the chemicals being used, under pressure such that they pass into the perforations and so seal off the well shaft from the surrounding area. The perforation process is then repeated at further points within the shaft, chemicals introduced as required and the other points sealed off in the same way if required. When oil production is started/resumed from the area, if polypropylene spheres

have been used then they are forced out of their sealing positions (by the release of the retaining pressure) and carried with the flow of the oil to a point where known means are present to enable their removal. If wax frits are used then, due to the increased ambient temperature at the normal depth at which oil wells are located, the frits are released from their sealing position (by the release of the retaining pressure) such that they are melted by the hot oil and so do not require removal from the resulting flowing oil.

Another process carried out in the oil/gas industry uses the same chemicals to unblock strata, via previously made perforations, which have become blocked during oil production. Polypropylene balls or wax frits (sealants) are also used in this case but they result in the blockage of the perforations into which the chemicals initially flow such that the subsequent flow of chemicals is directed to other perforations and hence other blocked strata areas. In this way a number of previously blocked areas of strata can be treated before the pressure is released which is keeping the sealants in place, resulting in a resumption of the flow of oil from the area.

However, due to the small size of the frits used in these processes and their non-uniform shape, they are not readily transported to the area which is required to be sealed off and the process requires a build up of the frits in the perforations (some frits pass through the perforation) thus resulting in the need to use large quantities of the frits to seal off the perforations.

There are also problems associated with the transfer of the frits down the apparatus used to deliver them to the relevant area. Due to their irregular shape they tend to block the transfer lines used in the transfer process.

There therefore exists a requirement for a material which can be used in the aforementioned sealing processes which has the shape and resulting flow characteristics of the polypropylene spheres currently used in combination with the beneficial melting properties associated with the use of wax frits. The current invention seeks to provide a solution which addresses these issues.

Summary of the Invention

In a first aspect, the invention provides a diverter for use in multizone stimulation processes and characterised in that it comprises a ball consisting of wax with an appropriate melting point, size and specific gravity for use in the stimulation process. Diverters are also known as Frac Balls.

Preferably the diverter comprises wax and an appropriate diluent.

Preferably the diverter comprises a ball which is spherical.

In a second aspect, the invention provides a method of producing a diverter suitable for use in multizone stimulation processes, the method being characterised by the features,

a) that the process used to produce the diverters is an injection moulding process;

b) that the material used in the process is wax with or without any necessary diluent, of a melting point and specific gravity appropriate to the intended use; and

c) that the mould cavities defining the shape of the moulded products are ball-shaped.

In a third aspect the invention provides a multizone stimulation process comprising the steps of:

a) chemically treating an area to improve the flow of oil or gas through rock strata;

b) sealing the chemically treated area by insertion under pressure of diverters into the walls of a well shaft ; and

c) subsequently releasing the diverters to allow oil to flow;

characterised by the use of diverters in the form of wax (or wax-based) balls of an appropriate size, specific gravity and melting point that, on release of the sealing pressure, they melt as they are carried upwards in the oil flow.

Included within the scope of the invention is a diverter for use in multizone stimulation processes substantially as described herein with reference to and as illustrated by any appropriate combination of the accompanying drawings.

Brief Description of the Drawings

Figure 1 is a perspective view of one of the stainless steel block halves that makes up a two-part mould suitable for forming wax spheres.

Description of the Preferred Embodiment

In this embodiment, wax spheres are produced by injecting into a two-part mould a wax with an appropriate melting point. The spheres described herein are 5/8 of an inch (16mm) or 7/8 of an inch (22mm) in diameter and this particular embodiment uses paraffin wax with a melting point of 155°F.

It will be appreciated by those skilled in the art that other waxes with appropriate melting points could also be used such as vegetable waxes and other manufactured and naturally occurring waxes with appropriate melting points. Paraffin wax typically comprises solid saturated hydrocarbons with the molecular formula C_nH_{2n+2}. Wax is used in the current application as it is inert with respect to the acidic chemicals used in the multizone stimulation process described herein and additionally is soluble in crude oil which is at a temperature above the melting point of the wax.

The mould half of Figure 1, and its mirror-image complementary half (not illustrated) mould to be used in the process described herein is treated with an appropriate agent to promote release of wax spheres produced, preferably before the two-part mould used herein is assembled.

The mould, when assembled, defines one or more (in practice, many) rows of hollow spheres formed within two blocks of stainless steel. Channels (13) are provided within

the blocks such that each hollow sphere 12 is connected to its immediately adjacent neighbouring spheres.

Molten wax is forced into the mould under pressure via a single inlet (11) leading into a sphere (15) defined in a central portion of the mould. The wax is then forced by applied pressure along the channels (13) to adjacent hollow spheres. In this way the hollow spheres fill with wax, from the side to which the inlet is connected, to the opposite side which incorporates a series of channels forming outlets (14) through which air contained in the mould is forced out as the molten wax fills the mould. It is important that there are no air pockets in the formed wax spheres.

The wax is then allowed to cool and the wax spheres then contained within the mould are released by separating the two blocks that form the mould.

These wax spheres when used in the process of multizone stimulation are required to have a specific gravity similar to or the same as the chemicals used to break down the rock structure. The reason for this is that as the spheres used must be transported with the chemicals being used, if they have a lower specific gravity they will float in the chemical (gel/liquid), if they have a higher specific gravity they will sink in the chemical gel/liquid. In either of these cases a problem will be generated in that the spheres are not readily transported to the required areas. The result of this is that larger quantities of wax spheres must be used to seal off the broken down rock structure before starting the multizone stimulation at other points.

By making the density of the spheres the same as or similar to the chemical fluids being used the spheres are readily transported by the chemicals being used. The specific gravity of the fluids normally used is 0.9, 1.1, 1.2 or 1.3 relative to water at 25°C. Spheres of the appropriate specific gravity are produced by first mixing the wax used with appropriate quantities of diluents such as calcium carbonate and/or talcum powder which are used in a powdered form. The appropriate ratio of diluent to wax can be determined.

The reason for using these particular diluents is that they are inert with respect to the paraffin wax used herein. Various other materials could be used as diluents such as other aluminosilicates, potassium carbonate, calcium chloride and the like.

The current process uses a vertically mounted mould which is filled from top to bottom via the inlet (11).

In use, the size of the spheres used is determined by the diameter of the perforations created by the perforating gun in the well wall. A suitable quantity of wax spheres (typically 150 – 200) is injected into the flow of the chemicals being used (treatment fluid) by means of a transfer/injection gun.

The wax spheres are transported into the perforations in the wall of the well using the chemicals being used to break down the rock strata, the temperature in the well and immediate area having been reduced below the melting point of the wax being used by the flow of the stimulation chemicals used. The wax spheres are forced into the perforations in the wall of the well under pressure and form a seal such that the multizone stimulation process can be repeated elsewhere - or alternatively, other processes can be carried out. Positive pressure is applied to keep the spheres in place until the multizone stimulation process or other processes are complete. Release of the applied pressure results in the flow of oil/gas up the drilled shaft. The temperature within the shafts rises as a result of this to a point in excess of the melting point of the wax. The molten wax then dissolves in the oil such that there is not the previous need to manually recover the known propylene spheres from the flow of oil/gas.

The paraffin waxes used in the embodiment described herein can be obtained from the following suppliers:

Paraffin waxes with melting points of 155°F, 180°F can be obtained from the following suppliers;

AUBIN Chemical Solutions, Aberdeen (GB);
RAW Chemical Distribution Limited, Great Yarmouth (GB); and

EGGAR & Co (Chemicals) Limited, Reading (GB) who are the distributors for Eastman Chemical Company in the USA.

Paraffin waxes with a melting point of 220°F are available from RAW Chemicals (GB) and EGGAR & Co (Chemicals) Limited (GB).